WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: OK4481

Title: Resistance Tomographic Imaging, Digital Mapping, and Immersion Visualization of Evaporite Karst in Western Oklahoma

Focus Categories: Groundwater, None

Keywords: digital mapping, visualization, evaporite karst, Oklahoma, contaminant transport, resistivity imaging, groundwater pollution

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Congressional District: Oklahoma 4th

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Abstract

The ability to detect the occurrence, location, volume and geometry of the network of solution-enlarged conduits in karst environments is critical to the proper management and conservation of water resources because these factors control groundwater movement and contaminant transport. Karst systems are especially susceptible to water pollution because the injection of surface waters directly into the subsurface through sinking streams introduces contaminants into the aquifer, which are subsequently transmitted at high conductivities in the discrete network of solutional conduits. Conventional site characterization typically involves intensive field programs of drilling and core sampling, downhole geophysical logging, well monitoring, hydrochemical and spring discharge hydrograph analysis. However, even with closely spaced networks of continuously sampled boreholes, significant uncertainties can arise in determining the lateral continuity and true subsurface geometry of solutional conduits. Stratigraphic resolution can be significantly improved in applied investigations by integrating conventional borehole information with continuous subsurface-imaging techniques such as Electrical Resistivity Tomographphy (ERT).

ERT using the new Swift SystemTM with programmable electrodes and new efficient inversion software generates a near continuous image of the subsurface, providing the most compelling evidence for the occurrence, location and geometrics of conduits. Although the system has been extensively used to detect subsurface voids and cavities, few studies have undertaken a systematic evaluation of its accuracy and resolution at various depths. Such an evaluation is necessary in order to develop sufficient confidence in the procedure that permits its application to new environments about which little information is available. This project will evaluate the detection capability of ERT.

Our goal is to determine the smallest dimensions of cavities and voids that are detectable with confidence at different depths and to assess the ability to identify subsurface karst that have comparable dimensions but different shapes such as voids and vertical shafts. A known cave system will be imaged from the surface using ERT and three array configurations including Schlumberger, Werner and dipole-dipole. At the same time, a GPS referenced reflectorless laser Range Finder linked to GIS and computer-aided design (CAD) software will be used to generate a comprehensive and high precision digital map and the degree of concurrence or variation assessed using suitable statistical techniques and modern 3-D visualization. By performing several such field experiments in different karst environments, we will determine the factors that impact on resolution and detectability. The digitally mapped cave will be imported into the conCAVE Immersion Visualization system and used to analyze conduit distribution and network connectivity.

The methods and field procedures developed will be used to map subsurface karst for which only surface information exists, e.g. the trajectory of a disappearing stream. Test drilling will be carried out to verify the accuracy of the result. Subsequent research will expand the range of geotechnical methods to include ground penetrating radar and seismic methods. In addition to being able to detect subterranean conduit network and geometry for contaminant management in karst aquifers, ERT has the potential to reduce the cost of applied investigations by reducing by reducing the total number of boreholes required to characterize a site.